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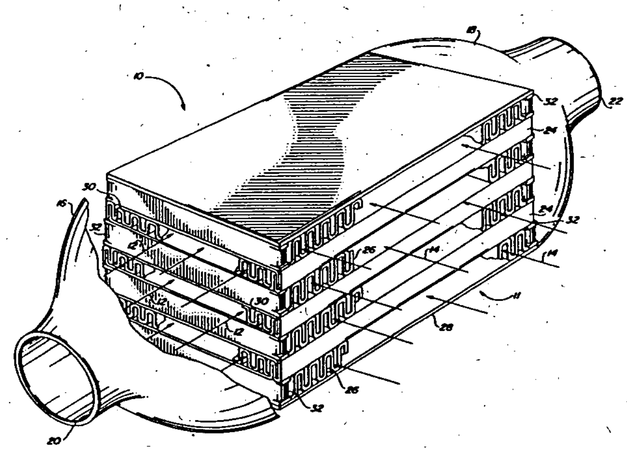
(54) **Heat exchanger tube.**


(57) A heat exchanger (10) has a core (11) built up from a stack of layers. Each alternate layer consists of a tube (24) bult up from two identical U-shaped members (40, 41) having a folded and unfolded side. The unfolded side (44) of each is slid into the fold (48) of the other. Fins (30) are fitted in the tube (24). The intervening layers are defined between a pair of header bars (32) with fins (26) between them. Outer plates (28) and manifolds (20, 22) complete the heat exchanger (10).

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# HEAT EXCHANGER TUBE

This invention relates to a heat exchanger construction, and one object is to provide a design which has a large heat exchange surface area for a given overall volume.

Heat exchangers in general are well known in the prior art, and typically comprise a heat exchanger core having dual fluid flow paths for passage of two fluids in heat exchanger relationship with each other without intermixing. In one common form, such heat exchangers typically comprise a plurality of relatively thin divider plates arranged in an alternating stack with a plurality of extended surface heat transfer elements, such as corrugated fins and the like. The extended surface heat transfer elements, or fins, are commonly turned alternately at right angles with respect to each other to define two closely adjacent fluid flow paths for passage of the two working fluids at right angles to each other. This construction is commonly known as a cross flow heat exchanger, and includes appropriate header bars along side margins of the stack to isolate the two working fluids from one another. When the stack is assembled, the various components thereof are commonly secured together, preferably in a single bonding operation, such as brazing or the like.

Heat exchangers further require some type of manifold or header structure for guiding at least one of the working fluids for ingress and egress with respect to its associated flow path through the heat exchanger core in isolation from the other working fluid. For example, when the heat exchanger is used to transfer heat energy between a liquid and a gas, the

liquid is normally supplied through an appropriate inlet conduit to an inlet manifold connected to the heat exhcanger core. The inlet header guides the liquid for flow into and through one of the flow paths in the core in heat transfer relationship with the gas which typically flows freely without headers through the other core fluid flow path. An outlet header connected to the heat exchanger core collects the liquid discharged from one of the fluid flow paths for passage away from the heat exchanger through an appropriate outlet conduit.

Manufacturers of vehicles employing internal combustion engines generally dictate the size and location of under-the-bonnet accessories supplied by manufacturers of these accessories. Therefore, once the particular space limitations are placed upon the supplier, it is of utmost importance to design a component which fits within that space limitation and meets the vehicle manufacturer's performance requirements. In the case of heat exchangers, once given the space limitations on the heat exchanger, it is important to maximise the heat and weight transfer characteristics in order to minimise the size of the overall heat exchanger. In order to accomplish this, it is necessary to maximise the cooling of the hot liquid coolant exiting the engine.

A common problem with the heat exchangers of the prior art rests in their design of the liquid core flow path. More specifically, these heat exchangers utilise a solid header bar on either side of the corrugated fins to define the core fluid flow path. As such, these solid bars do not provide a maximisation of the heat transfer between the hot liquid flowing through

the flow path defined by these solid bars and the cooler gas flowing in cross-flow relationship thereto. The solid bars also contribute to substantial weight penalties.

The present invention overcomes the problems and disadvantage of the prior art heat exchangers by providing an improved heat exchanger construction including tubes which eliminate the need for solid bars and, more importantly, maximise the fin density within the core passage.

In one form of the invention, a first fluid flow path is defined by a plurality of tubes which are spaced apart from the adjacent tube by two formed headers. The second or cool fluid flow path is defined by a plurality of cross-flow spaces between the plurality of tubes and the formed headers. Generally, the end passages of the core are cross-flow spaces and require solid end plates to define the outermost boundaries of the cross-flow space.

Each tube may be formed from two identically formed members which are complementary to each other. Thus, the tube members may be of generally U-shape having an elongated base section and upright sides. One side of each of the members is folded back over itself twice, to form a trough which runs the length of the member. The two identically formed complementary members are then placed one on top of each other with the non-folded side of each member being inserted to the trough of its complementary member. Assembled in this manner, the two pieces form a fluid core flow path therebetween. Inserted between the two members either before or after assembly thereof may be a corrugated heat transfer element fin. Tubes formed in this manner

are alteranted with formed headers running at right angles thereto.

The formed headers define the boundary width of each of the smaller second flow paths. The formed headers may be of generally C-shape in cross section and include a lanced tab extended from its central portion at each horizontal end thereof. The tabs at each end of the headers are folded inward. Inserted between the two formed headers during assembly of the heat exchanger core is a corrugated heat transfer fin element. The spaced headers thereby define the width of the second flow path while the two tubes spaced by the headers define the height of the second small passages. Once the desired number of tubes and pairs of formed headers have been stacked, side plates are placed over the exposed extended surface heat transfer elements of the cross-flow path. Manifolds are then attached to the core ends to which the first fluid paths are open.

The invention includes the tube itself from which the core may be built up, and the method of constructing the core.

Another aspect of the invention is the building up of the heat exchanger core from a number of components, e.g. tube members, headers, fins, and plates, all formed from sheet material and brazed together in a unitary construction.

The invention may be carried into practice in various ways, and one embodiment will be described by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a heat exchanger;

Figure 2 is a partial perspective view of two components of the heat exchanger;

Figures 3A and 3B are partial perspective views of an end bar of the heat exchanger, respectively before and after final forming of a lanced tab; and

Figure 4 is a perspective view of the heat exchanger core during assembly.

The heat exchanger 10 includes a core 11 defining a pair of internal flow paths 12 and 14, for passage of two working fluids in heat exchanger relationship and at right angles to each other. One of the working fluids is coupled for flow to and from the heat exchanger 10 through an inlet manifold 16 and an outlet manifold 18. These manifolds 16 and 18 are mounted integrally with the heat exchanger core 11 and respectively include fluid fittings, 20 and 22, for connections to the appropriate conduits.

The heat exchanger 10 is easily assembled from its various components, and then those components are connected to each other in a single bonding operation such as brazing.

The flow path 12 for the said one fluid, for example, a liquid coolant, is formed from a stack of spaced tubes 24 each formed from two similar components as shown in Figure 2.

Successive tubes 24 are spaced apart by a pair of formed header bars 32 extending perpendicular to the flow direction in the tubes, one at the inlet end, and one at the outlet end of the tubes. The tubes 24 include corrugated fins 30 which run the length of the tube.

The flow path 14 for the second fluid, for example, free flowing ambient air, is made up of a

number of spaced passages between adjacent tubes 24 with a width corresponding to the space between two header bars 32. Each passage includes corrugated fins 26 having portions in good contact with the tube walls above and below. The top and bottom passages in the second flow path 14 are each closed by a plate 28.

Each tube 24 is formed from the mating of two identical members as shown in Figure 2 at 40 and 41. Each member is generally U-shaped having a wide base 42 and upstanding perpendicular sides 44 and 45. The side 45 of each member is folded over, first back towards the base and then away from the base with a space or trough 48 between the two outer folds, which extend the length of the tube member. A tube 24 is formed by placing member 41 upside down in relation to member 40 and sliding the unfolded side 44 of each member into the trough 48 of the other member. Located within the tubes 24 are corrugated fin elements 30 (Figure 1) with portions in good contact with the bases 42. The wall thickness of the tube components may be as thin as 0.010 inches (0.25 cm).

As can be seen from the drawings, the bases 42 of the tube members prevent the mixing of the two working fluids in the respective flow paths. The bars 32 at the sides of the flow path 14 are formed with lanced end tabs 34 at both ends, by cutting and folding as shown in Figures 3A and 3B. The lanced tabs 34 are folded over at each end to provide increased compression corner strength, a land to weld flanges or manifolds to, and a restriction of the gap between each bar 32 and its adjacent fin 26. The bars 32 are generally C-shaped in cross-section with a web between two flanges which provide a generally stable base on

which to stack the tubes 24.

The opposite ends of the second flow path 14 are exposed for open flow of gas without any manifold or header structure. This gas passes in heat exchange relationship with the first working fluid coupled for flow through the first flow path 12.

The first flow path 12 is isolated from the second flow path 14 to prevent physical intermingling of the two working fluids. Thus, the inlet and outlet headers 16 and 18 are mounted at opposite ends of the first flow path 12 defined by tubes 24, and there is no communication with the second flow path 14 around the corners of the core 11.

Figure 4 shows how the core is built up. Four corner bars 50 are set at a predetermined distance from each other. Each corner bar 50 includes a squared cutaway section 52. A heat exchanger bottom plate 28 is placed on a flat surface of a bonding fixture and a layer of two header bars 30 separated by fins 26 is laid on it to define a second fluid passage. An assembly of two tube members and fins 30 is laid on the first layer to define a first fluid passage, and so on until the desired height is reached.

It will be noted that the base 42 of each tube is in intimate contact on one face with parts of the fins 26, and on the other face with parts of the fins 30.

A second heat exchanger plate 28 completes the last of the second fluid passages. An upper portion of a bonding fixture is placed atop the second plate in order to hold the core in place during the bonding of the pieces together. Thereafter, the heat exchanger core 11 is bonded by a single metallurgical bonding operation, such as brazing. The tubes 24, header bars

32, fins 26 and 30, and plates 28, are all coated with braze alloy so that the stacked core can be clamped and subjected to the requisite bonding temperature. Manifolds 16 and 18 are welded to the core at opposite ends of the tubes 24. The folded sides of the tube members 40 and 41 give the tube a thickness at its sides which is four times the thickness of the tube material. This ensures that the manifolds 16 and 18 can easily be attached by welding directly to the core face where the two members 40 and 41 have been joined and to the ends of the header bars 32.

## CLAIMS

1. A tube (24) for use in a heat exchanger (10), characterised in that the tube is formed from two elongate members (40, 42) of generally U-shaped section, each member having a base (41) and two sides (44, 45), of which one side (45) is folded to define a trough (48) for receiving the other side (44) of the other of the two members.

2. A tube as claimed in Claim 1, in which the two members are similar or identical.

3. A tube as claimed in Claim 1 or Claim 2, in which each of the elongate members is folded from sheet material.

4. A tube as claimed in any of the preceding claims, including corrugated fins (30) fitted within the tube.

5. A tube as claimed in any of the preceding claims, in which each side of the tube has a thickness equal to at least several times the thickness of the base (41).

6. A heat exchanger in which a first fluid flow path is defined by a stack of tubes, each as claimed in any of the preceding claims, which are spaced apart in the stack by headers (32).

7. A heat exchanger as claimed in Claim 6 in which the headers are folded from sheet material.

8. A heat exchanger as claimed in Claim 6 or Claim 7, in which fins (26) occupy the space between adjacent stacked tubes, and between a pair of headers (32) holding the tubes in spaced relationship, the space occupied by the fins constituting a second fluid flow path.

9. A heat exchanger as claimed in Claim 8 including outer plates (28) defining the extreme spaces constituting second fluid flow paths.

10. A heat exchanger as claimed in any of Claims 7 to 9 in which each header comprises a web (34) and flanges (32) giving substantial stacking areas, even though the headers are formed from sheet material.

11. A heat exchanger as claimed in any of Claims 6 to 10, in which the elongate members, tubes, headers, fins and outer plates are brazed together in a unitary assembly.

12. A heat exchanger as claimed in any of Claims 6 to 11 including an inlet and an outlet manifold (16, 18) united with the heat exchanger core and in communication with one of the fluid flow paths, but not with the other.

13. A heat exchanger built up from a number of components (40, 42, 26, 30, 32, and 28) all formed from sheet material and brazed together in a unitary assembly.

14. A method of constructing a heat exchanger core comprising the steps of:

a) securing four corner posts to a surface at a predetermined distance from one another, each post having a squared cut-out portion;

b) placing a side plate between said post on the surface;

c) constructing a plurality of tubes having corrugated fins therein;

d) placing two formed header bars atop said plates, each bar extending between two posts;

e) placing an extended heat transfer element between said two formed header bars;

f) placing a formed tube atop the spacer unit;

g) repeating the above steps d, e and f until the heat exchanger core of the desired dimensions is constructed;

placing two formed header bars atop said plates, each bar extending between two posts;

placing an extended heat transfer element between said two formed header bars; and optionally

placing a second side plate atop the last pair of formed header bars and extended heat transfer element; and

brazing the two side plates, plurality of tubes, formed header bars and extended surface heat transfer elements together forming the heat exchanger core.

15. The method according to Claim 14, wherein said steps of constructing a plurality of tubes comprises the steps of:

forming members having a generally U-shaped cross-section including a base and an unfolded leg and a

twice folded leg;

placing a corrugated heat exchanger fin within a first member; and

securing a second member to the first member to form the tube.

16. The method according to Claim 15, wherein said step of securing a second member to a first member comprises the steps of:

rotating said second member 180° with respect to the length of said base;

sliding the said unfolded leg of each member between the folds of the folded leg of the other member.

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# EUROPEAN SEARCH REPORT

0245022

Application number

EP 87 30 3843

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| Y | FR-E- 29 315 (HUBERT) * Whole document * | 1-3,5 | F 28 D 1/03<br>F 28 F 3/08 |
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| Y | DE-C- 366 869 (REBLE) * Whole document * | 1-3,5 | |
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| A | PATENT ABSTRACTS OF JAPAN, vol. 8, no. 69 (M-286)[1506], 31st March 1984; & JP-A-58 217 193 (TOKYO SHIBAURA DENKI K.K.) 17-12-1983 | 14 | F 28 D<br>F 28 F |
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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 07-08-1987 | HOERNELL, L.H. |

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| A | US-A-4 350 201 (STEINEMAN) --- | | |
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| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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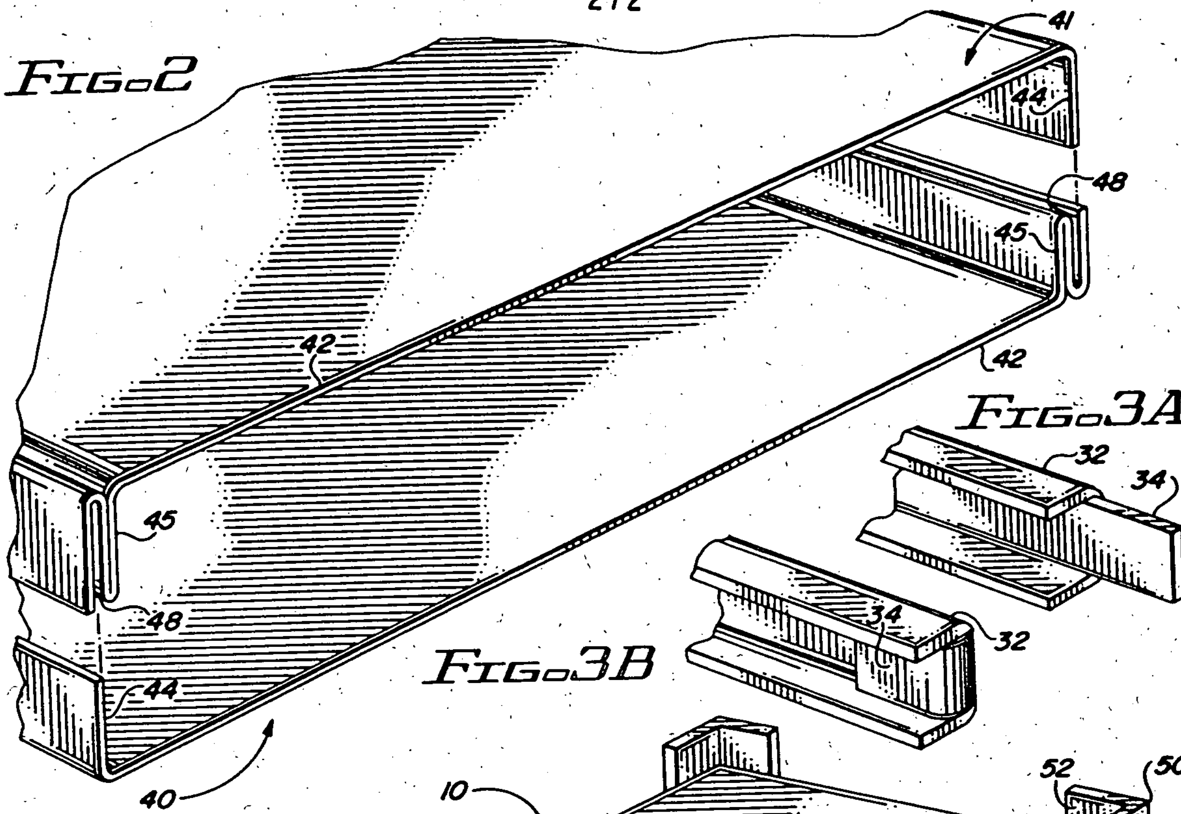
FIG. 2

FIG. 3A

FIG. 3B



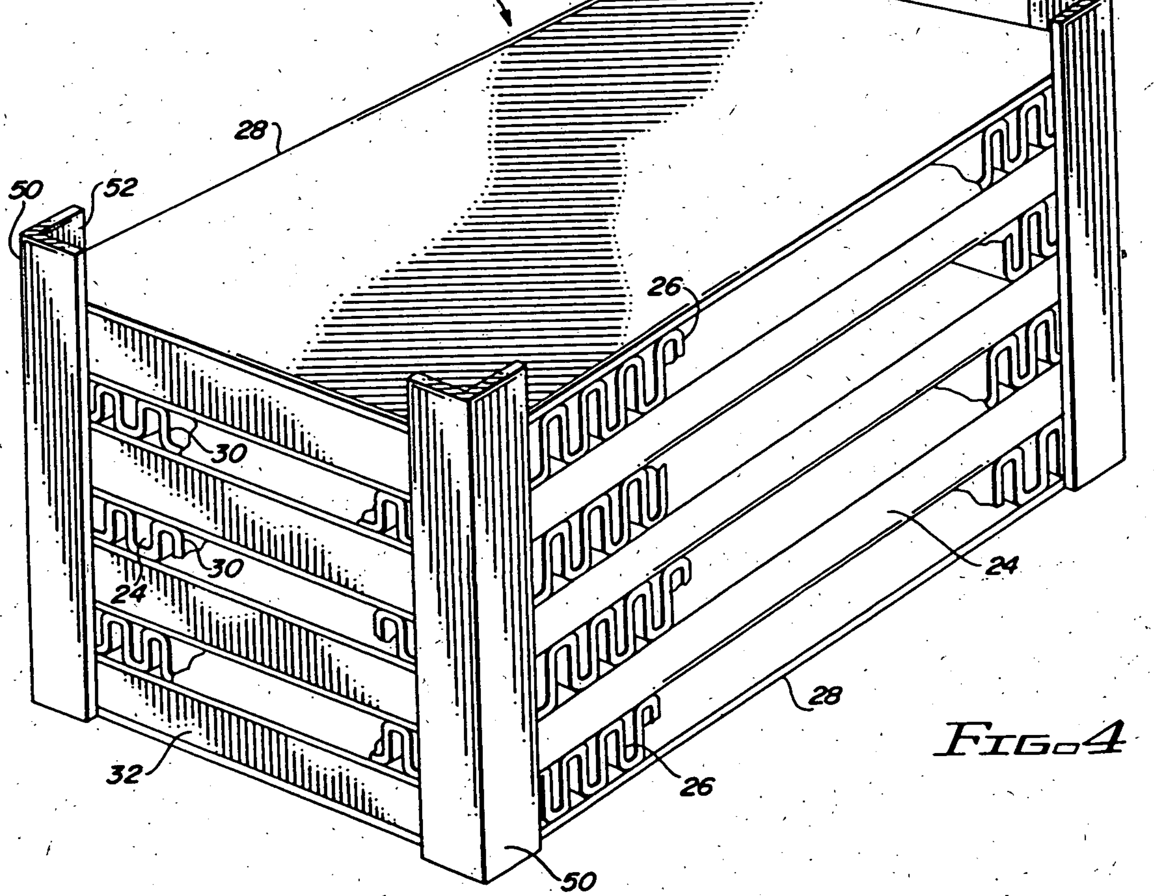




FIG. 4

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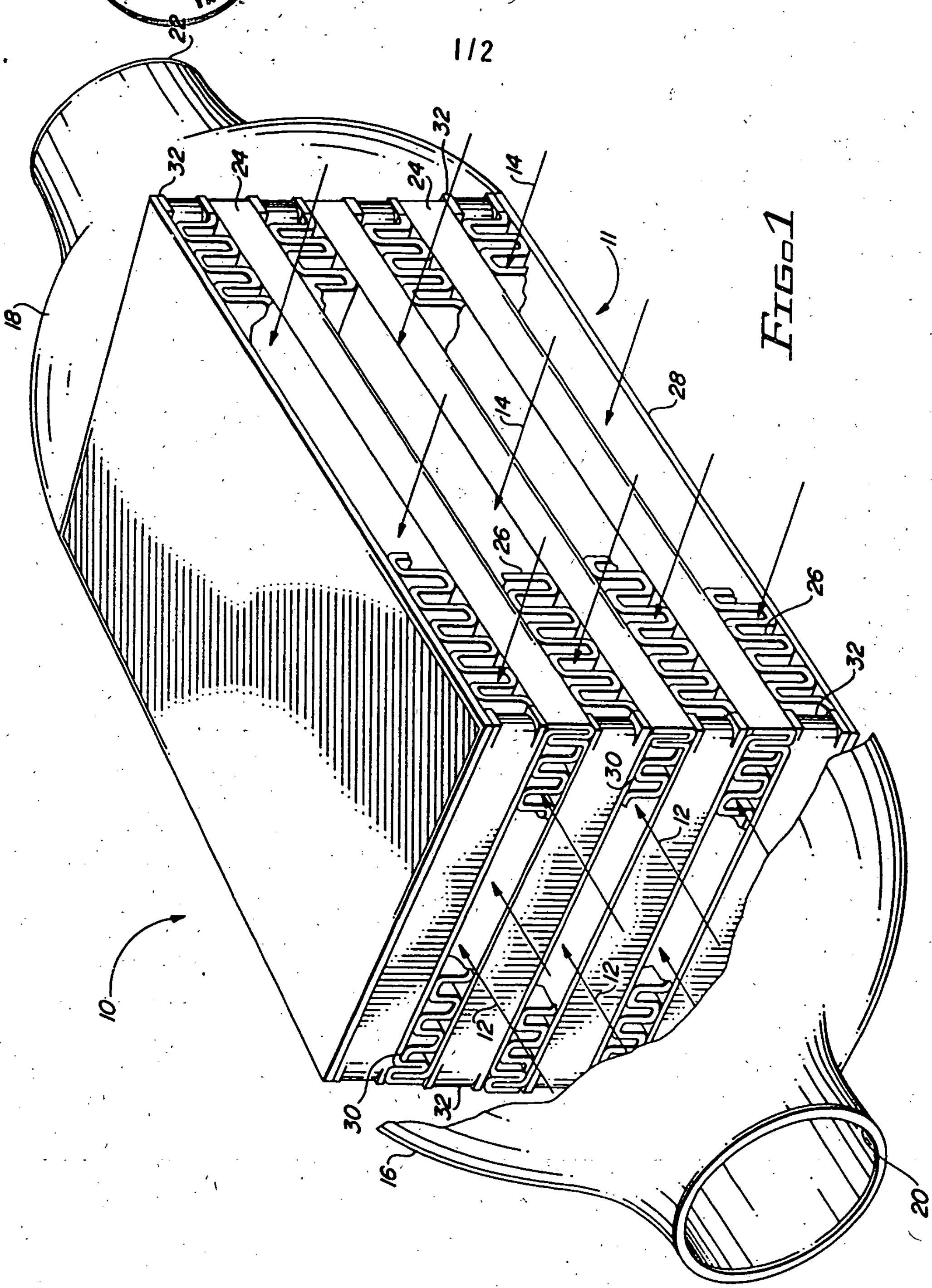


FIG. 1